# Why a Planetary Boundary, If It Is Not Planetary, and the Boundary Is Undefined? A Reply to Rockström et al

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# Why a Planetary Boundary, If It Is Not Planetary, and the Boundary Is Undefined? A Reply to Rockström *et al.*

José M. Montoya,[1,*] Ian Donohue,[2] and Stuart L. Pimm[3]

Nothing validates our concerns about Rockström *et al.*'s work more than their response to our critique of it. First, they state 'a planetary boundary . . . is not equivalent to a global threshold or tipping point'. While we appreciate this statement, we struggle with understanding their distinctions between tipping points, planetary boundaries, safe operating space, resilience, and irreversible changes, terms we show permeate their work from its onset to the present.

Second, they continue their now well-established downward slide toward undefined, indeed undefinable, speculations entirely devoid of scientific content.

The original paper discusses 'planetary boundaries', arguing that the global extinction rate is now well outside a 'safe operating space'. In the context of biodiversity loss, it discusses 'biodiversity in preventing ecosystems from tipping into undesired states'. It self-cites Folke *et al*. [1] for this, who in their brief abstract discuss how 'ecosystems may suddenly shift from desired to less desired states.' In 2017, Rockström reported that the world massively changed 'quite precisely in 1989' [2].

Also in recent presentations [2,3], Rockström talks about 'massive advances in tipping point research' noting that, despite years of exhaustive comments on planetary boundaries, 'nobody is arguing that we got one of the nine wrong'.

In these and recent publications, he repeats the original figure, complete with the rhetoric of 'resilience', which in their context means whether a system can return to its original state or whether it will suffer 'irreversible changes'.

While the figure has not changed, its labels have. Extinction rate appears again in an early 2017 publication, but has been replaced with 'genetic diversity' in an online response to our concerns [4]. Genetic diversity is clearly important, but is not defined, and is currently impossible to measure at a planetary scale. Interestingly, the principal driver of species extinction and genetic loss – land-use change – is curiously nowhere near the purported boundary in any of the versions.

In a response to our critique, Rockström and colleagues described their ideas 'in a nutshell, if the tipping point is the cliff, the planetary boundary is the fence near the cliff'. Although graphically entertaining, alas, this does not provide useful insight.

What remains is as unsatisfactory as before. Rockström *et al*. started with species extinction rates. Now, we are left with an 'updated biosphere integrity boundary', the meaning of which is obscure, the units of which are undefined, and the measurement of which is left unstated. Later attempts for clarification are welcomed, but they are unsatisfactory. Moreover, these new metrics bring into question the global scale of any putative boundary, as they can really only be established locally [5].

Rather than object to our well-intentioned criticisms, Rockström and colleagues should take this opportunity to decide which terms they wish to use, identify their units, indicate how to measure them, explore their interrelationships, and be explicit about the wider consequences of their changes.

[1]Theoretical and Experimental Ecology Station, CNRS-UPS, Moulis, France
[2]School of Natural Sciences, Trinity College Dublin, Dublin, Ireland
[3]Nicholas School of the Environment, Duke University, Durham, NC, USA

*Correspondence:
josemaria.MONTOYATERAN@sete.cnrs.fr (J.M. Montoya).

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